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INFRARED (2.08-14 μm) SPECTRA OF POWDERED STONY METEORITES.

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Infrared biconical reflectance spectra of 60 powdered meteorite samples, representing 50 different stony meteorites, have been measured as analogues of asteroidal regolith. Representative samples have also been measured in directional hemispherical reflectance to assure that Kirchhoff's Law can be used to predict relative emissivity from the reflectance spectra[1].

These spectral data confirm that the O-H fundamental absorption band near 2.9 μm is an extremely sensitive indicator of incipient alteration[2,3], which often has taken place in powdered meteorite samples exposed only to water vapor in the air. Such non-carbonaceous samples typically contain less than 1% water by weight.

Likewise, the C-H fundamental absorption bands near 3.4 and 3.5 μm are equally sensitive indicators of contamination with volatile hydrocarbons, which can also be adsorbed from the air. The heavy, macromolecular hydrocarbons native to chondrites do not display such bands, making detection of these bands in remote sensing of asteroids[4] unlikely.

Despite the spectral artifacts introduced by alteration and hydrocarbon contamination, powdered stony meteorites display a wide variety of real spectral features that can be used for their identification. These include:

<u>Residual reststrahlen bands</u>. Ever since Lyon[5] showed that fundamental molecular vibration bands, or reststrahlen bands, become difficult to detect in the spectra of fine particulate materials, efforts have been made to determine alternative spectral features (see below) that can be used to characterize composition in the mid-infrared region of the spectrum. However, our meteorite spectra show that, although reststrahlen bands become subtle compared to other features in the spectra of fine (<75 μm) particulate material, they do not completely disappear. Some minerals, such as olivine, have particularly persistent reststrahlen features that remain easily discernable, while other minerals contribute more subtle features, but all can be used for meteorite identification in spectra with sufficient spectral resolution and signal-to-noise to resolve them.

Absorption bands. While the strong reststrahlen bands of the major meteorite-forming minerals are dominated by surface scattering, and hence are expressed as reflectance peaks, other bands occur in the 4 to 7 μm region that have much weaker absorption coefficients. As a result, volume scattering dominates the spectral behavior in this region and these bands are expressed as troughs. Such overtone and combination tone bands have compositional significance for many particulate materials[6], and meteorites are no exception. Both olivine and pyroxene have prominent spectral features in this region that change wavelength position with iron content of the minerals.

Christiansen feature. The reflectance minimum associated with the Christiansen frequency has been shown to be indicative of the compositions of minerals and rocks[7,8]. Most naturally occurring mineral mixtures result in a single average Christiansen feature, but when the individual minerals have Christiansen features that are too far apart in wavelength, a complex spectral feature may result. This occurs in spectra of some kinds of carbonaceous chondrites. In such a case, changing spectral resolution may substantially affect the apparent wavelength of the Christiansen feature. Thus, laboratory and remote sensing spectral data should be compared at the same resolution.

We find that the wavelengths of the peaks or troughs of each one of the spectral features described above can be used independently to infer meteorite composition (see Figure 1), but the best results are obtained when the entire spectral curve is used, or at least the portion of it encompassed by the 8 to 14 μm atmospheric window, in a digital search library. Effects of the vacuum environment on such a spectral curve[9] have yet to be fully assessed, but should be minimal for materials as dark as stony meteorites.

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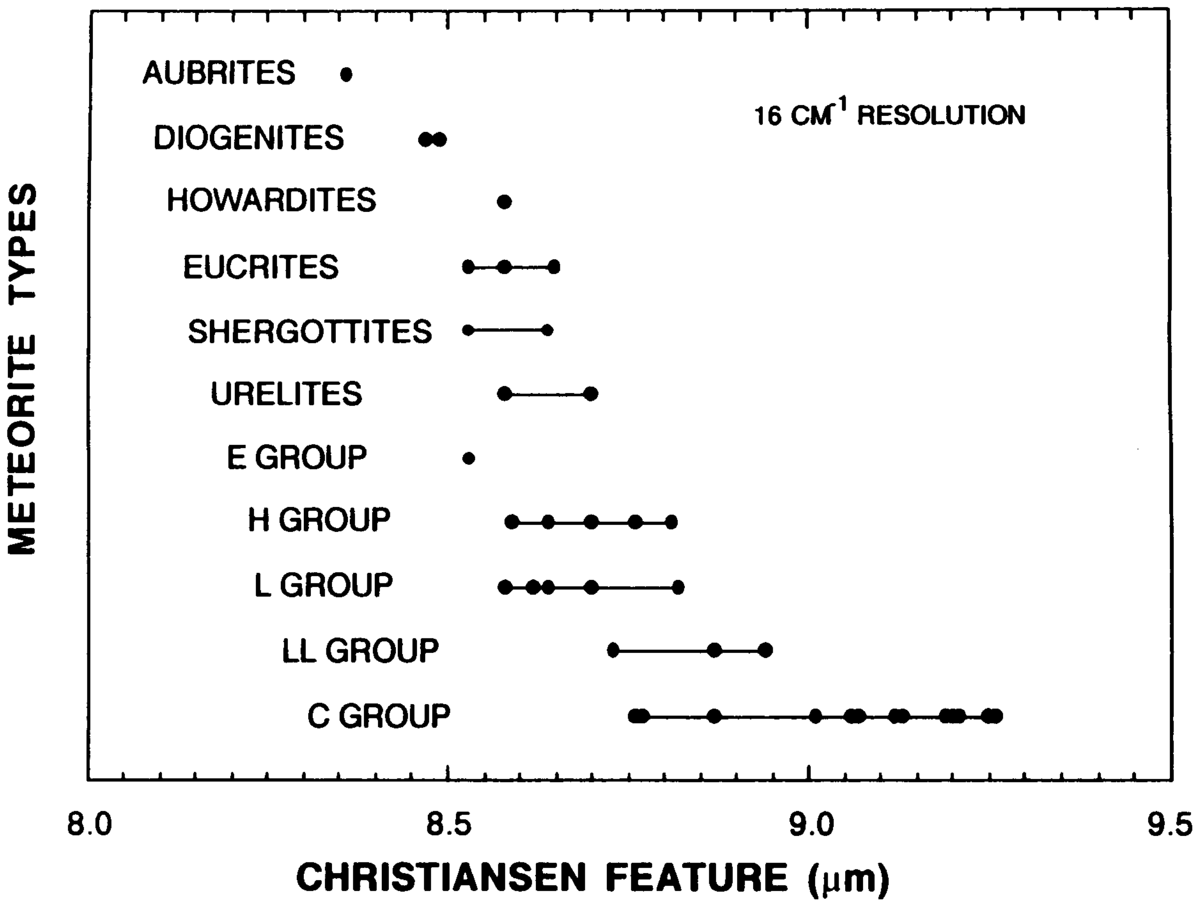

Figure 1. Wavelength of the Christiansen feature measured at 16 wavenumber resolution for all meteorite types examined.